NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	MTech Semiconductor Technology
Course Code:	6EC302CC24
Course Title:	Semiconductor Device & modelling
Course Type:	Core
Year of Introduction:	2024-25

L	T	Practical component				C
		LPW	PW	W	S	
3	-	2	-	-	-	4

Course Learning Outcomes (CLOs)

At the end of the course, students will be able to

1. comprehend the semiconductor physics and Quantum fundamentals (BL 2)
2. evaluate the modeling of single and two junction semiconductor devices (BL 3)
3. analyse the different Models of MOS structures (BL 4)
4. implement the different MOSFETs for VLSI circuit. (BL 5)

	Contents	Teaching hours (Total 45)
Unit I	**Semiconductor physics fundamentals** Metals, insulator, semiconductors, intrinsic and extrinsic semiconductors, direct and indirect band gap, free carrier densities, Fermi distribution, density of states, Poisson and Continuity equations, Boltzmann statistics, equilibrium carrier concentrations (electron statistics, density of states, effective mass, bandgap narrowing), current flow mechanisms, drift current, diffusion current, mobility, band gap narrowing, resistance, generation and recombination, lifetime, internal electro-static fields and potentials, Poisson's equation, continuity equations, drift-diffusion equations, Basic Quantum Mechanics, Crystal symmetry and band structure, 2D/1D density of states, Tunnelling	**10**
Unit II	**Bi-junction transistor** Quantitative theory of bipolar junction transistors having uniformly doped region and heavy doping effects, double diffused transistors, Ebers-Moll model, static characteristics in Early effect, saturation and inverse operation, breakdown mechanisms, punch-through, Emitter efficiency, transport factor, junction and diffusion capacitance, transit times, parasitic, small-signal models.	**05**
Unit III	**MOS Basics Scaling and Effects of Scaling on MOS** MOSFET Basics, V-I Characteristics, MOSFET scaling, Small-geometry effects, MOSFET capacitances	**10**
Unit IV	**Modelling of MOS transistor** Basic concept of modelling, Various level MOS model equation, variation of channel length in saturation and subthreshold mode, BSIM Model, basic MOS capacitance model, gate-oxide and junction capacitance model, comparison of various level spice model	**05**
Unit V	**MOS transistor design issues**	**08**

Short channel and ultra short channel effects, effect on t_{ox} , effect of high k and low k dielectrics on the gate leakage and source-drain leakage, tunnelling effects, different gate structures in Ultra Deep Sub-Micron(UDSM), impact and reliability challenges in UDSM.

Unit VI **MOSFET devices** **07**

Schottky Barriers and Ohmic Contacts, Steps of Deriving a Device Model, Types of Device Model, MOSFET Models, Double Gate MOSFET, FINFET

Self -Study:

The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Laboratory Work:

Laboratory work will be based on the above syllabus with a minimum of 10 experiments to be incorporated.

Suggested Readings/References:

1. Y.P. Tsividis, The MOS Transistor, McGraw-Hill, international edition ed., 1988
2. Nandita DasGupta, Amitava DasGupta, Semiconductor Devices: Modeling and Technology, PHI
3. S.M.Sze, Semiconductor Devices Physics and Technology, John Wiley & Sons Inc

Details of Laboratory
Suggested List of Experiments

Sr. No.	Practical	No. of Hours
1.	Design a resistor and capacitor and simulate in Visual TCAD	02
2.	Design a PN Junction Diode (2D) device and Simulate in Visual TCAD.	02
3.	Design a Bipolar Junction Transistor(2D) and Simulate in Visual TCAD.	02
4.	Draw NMOS device (2D) and Simulate in Visual TCAD.	02
5.	Design PMOS device (2D) and Simulate in Visual TCAD.	02
6.	Design and implementation of CMOS using NMOS.	02
7.	Design and implementation of CMOS using PMOS.	02
8.	Design and Simulation of 2D CMOS inverter.	02
9.	Design and simulation of DGFET.	02
10.	Design and Simulation of 2D GaAs HEMT.	02
11.	Design and Simulation of Silicon on insulator NMOS.	02
12.	Modelling of various MOSFETs	02
13.	Channel effect on MOSFET part 1	02
14.	Channel effect on MOSFET part 2	02
15.	Channel effect on MOSFET part 3	02